

JPL VLBI Analysis Center Report for 2011

Chris Jacobs

Abstract

This report describes the activities of the JPL VLBI Analysis Center for the year 2011. We continue to do celestial reference frame, terrestrial reference frame, earth orientation, and spacecraft navigation work using the VLBI technique. In 2011 we continued to collect reference frame data at 448 Mbps. Our work to build a reference at X/Ka-bands (8.4/32 GHz) is close to ppb accuracy. We supported several missions with VLBI navigation measurements. We continue to study ways to improve spacecraft tracking using VLBI techniques.

1. General Information

The Jet Propulsion Laboratory (JPL) Analysis Center is in Pasadena, California. Like the rest of JPL, the center is operated by the California Institute of Technology under contract to NASA. JPL has done VLBI analysis since about 1970. We focus on spacecraft navigation, including:

1. Celestial Reference Frame (CRF) and Terrestrial Reference Frame (TRF) are efforts which provide infrastructure to support spacecraft navigation and Earth orientation measurements.
2. Time and Earth Motion Precision Observations (TEMPO) measures Earth orientation parameters based on single baseline semi-monthly measurements. These VLBI measurements are then combined with daily GPS measurements as well as other sources of Earth orientation information. The combined product provides Earth orientation for spacecraft navigation.
3. Delta differenced one-way range (Δ DOR) is a differential VLBI technique which measures the angle between a spacecraft and an angularly nearby extragalactic radio source. This technique thus complements the radial information from spacecraft doppler and range measurements by providing plane-of-sky information for the spacecraft trajectory.
4. Δ VLBI phase referencing uses the VLBA to measure spacecraft positions.

2. Technical Capabilities

The JPL Analysis Center acquires its own data and supplements it with data from other centers. The data we acquire are taken using NASA's Deep Space Network (DSN).

1. Antennas: Most of our work uses 34-m antennas located near Goldstone (California, USA), Madrid (Spain), and Tidbinbilla (Australia). These include the following Deep Space Stations (DSS): the "High Efficiency" subnet comprised of DSS 15, DSS 45, and DSS 65 (see Figure 1) which has been the most often used set of antennas for VLBI. More recently, we have used the DSN's beam waveguide (BWG) antennas: DSS 13, DSS 24, DSS 25, DSS 26, DSS 34, DSS 54, and DSS 55. Less frequent use is made of the DSN's 70-m network (DSS 14, DSS 43, DSS 63). Typical X-band system temperatures are 35K on the HEF antennas. The 70-m and BWGs are about 20K. Antenna efficiencies are typically well above 50% at X-band.

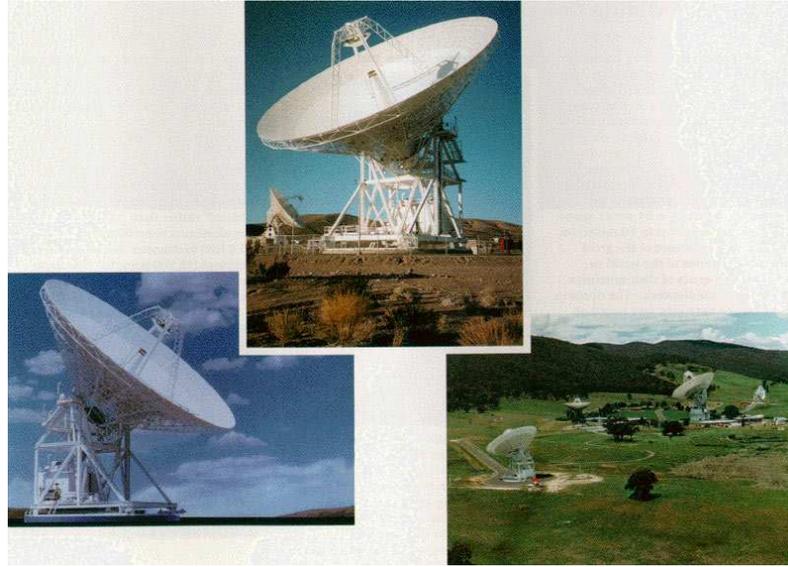


Figure 1. The three ‘high-efficiency’ DSN antennas: Goldstone (center); Robledo, Spain (lower left); and Tidbinbilla, Australia (lower right). These antennas were completed before 1986 for the Voyager Uranus encounter. In the 1990s, Ka-band (32 GHz) BWG antennas (not shown) were added.

2. Data acquisition: We use the Mark 5A VLBI data acquisition systems. In addition, we have JPL-unique systems called the VLBI Science Recorder (VSR) and the Wideband VSRs (WVSR) which have digital baseband converters and record directly to hard disk. The data are later transferred via network to JPL for processing with our software correlator.
3. Correlators: JPL VLBI Correlator has been exclusively based on the SOFTC software, which handles the Δ DOR, TEMPO, and CRF correlations as well as tests of antenna arraying.
4. Solution types: We run several different types of solutions. For Δ DOR spacecraft tracking we make narrow field ($\approx 10^\circ$) differential solutions. The TEMPO solutions typically have a highly constrained terrestrial (TRF) and celestial frame (CRF) as a foundation for estimating Earth orientation parameters. These reference frames are produced from global solutions which then provide the framework needed for use by TEMPO and Δ DOR.

3. Staff

Our staff are listed below along with areas of concentration. Note that not all of the staff listed work on VLBI exclusively, as our group is involved in a number of projects in addition to VLBI.

- Durgadas Bagri: VLBI instrumental calibrations and TEMPO.
- Jim Border: Δ DOR spacecraft tracking.
- Cristina Garcia-Miro: Field support of VLBI experiments at Madrid.
- Shinji Horiuchi: Field support of VLBI experiments at Canberra.
- Chris Jacobs: S/X, K, Q, X/Ka CRFs, and TRF.

- Peter Kroger: Δ DOR spacecraft tracking.
- Gabor Lanyi: VLBA phase referencing, Δ DOR, WVR, K-Q CRF, and TRF.
- Steve Lowe: Software correlator, fringe fitting software, Δ DOR.
- Walid Majid: Δ DOR, VLBA phase referencing.
- Chuck Naudet: WVR, Mark 5A support, and K-Q CRF.
- Andres Romero-Wolf: Δ DOR, CRF, and TRF. Maintains MODEST analysis code.
- Lawrence Snedeker: Field support of VLBI experiments at Goldstone.
- Ioana Sotuela: Field support of VLBI experiments and antenna calibration at Madrid.
- Ojars Sovers: S/X, K, Q, and X/Ka CRFs and TRF. Maintains MODEST analysis code.
- Alan Steppe: TEMPO and TRF.

4. Current Status and Activities

X/Ka-band (8.4/32 GHz) CRF work continues along with S/X CRF and TEMPO EOP work.

VLBI spacecraft tracking continues to provide measurements of angular position in support of mission navigation and planetary ephemeris development. The ESA mission Rosetta was supported for its deep space maneuver in February. The Messenger spacecraft was guided into orbit about Mercury in March. Dawn was guided to a rendezvous with asteroid Vesta in May. Delta-DOR measurements of the Deep Impact spacecraft were taken in conjunction with ranging to verify that the DSN can uplink a ranging signal from one complex and then receive it at a second complex. This scenario is needed for later New Horizons support, when the round trip light time will be so great that a ranging signal transmitted by one complex cannot return before the complex has rotated out of view. The New Horizons trajectory toward Pluto was verified in June. The JAXA mission Planet-C was supported during its engine checkout in October – November. Monthly measurements of MRO and Mars Odyssey continue to improve the ephemeris of Mars. Juno and MSL were launched in late 2011 and will be heavily supported with Delta-DOR in 2012.

5. Future Plans

In 2012, we hope to improve TEMPO and reference frame VLBI by increasing data rates to 2048 Mbps. Operational Ka-band phase calibrators have been built and are planned for deployment in 2012. Work on the Digital Back End (DBE) continues. Our next generation fringe fitting program is also expected to come online. We anticipate refereed publications on our X/Ka celestial reference frame work. On the spacecraft front, we plan to continue supporting a number of operational missions while further improving techniques for using VLBI for spacecraft tracking.

Acknowledgements

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